Chapter 14

Cost reduction strategies

In this Chapter we describe a number of possibilities for reducing the cost of the MINOS experiment in order to conform to the funding guidelines provided by Fermilab and the Department of Energy. At this time it appears the a cost reduction of about 20% will be required. We believe that a substantial part of this reduction will occur naturally as we continue to optimize the engineering details of the baseline design described in this Technical Design Report. Although the present baseline design and cost estimate are quite conservative, further optimization is likely to provide only part of the necessary cost reduction. Other strategies involve both reversible and irreversible changes to the baseline design. We hope that the required cost reduction can be achieved through the implementation of a carefully chosen set of changes which can be reversed at a later time if this is justified by our initial physics results. However, such changes will inevitably involve tradeoffs between the physics capabilities of an initial, reduced scope, experiment and the ultimate sensitivity of an upgraded experiment which would be justified if MINOS discovers neutrino oscillations.

We are currently investigating how costs can be reduced in the most effective way, with the minimum irreversible compromise of physics capabilities. We group the possibilities into five generic categories.

1. **Changes in major detector parameters**

   (a) Decrease the mass (i.e., number of planes) of the far detector. The main impact of a mass reduction is the loss of statistical sensitivity. However, costs do not decrease linearly with far detector mass because of substantial fixed costs (e.g., the near detector, and the engineering and setup of fabrication facilities), the need for fiducial cuts at the downstream end of the detector, and possible increases in the low price quotes we have obtained for very large quantity orders. We view mass adjustments as a final "vernier" that would be used to fine tune the scope of the experiment to meet the imposed cost ceiling.

   (b) Increase the steel plane thickness. This would reduce proportionally the number of active detector planes needed to instrument the 8 kt far detector, and so would reduce the cost per ton of detector. We are reluctant to adopt this solution because it compromises the energy resolution, event identification, and the sensitivity to oscillations at low neutrino energies (low Δm^2).

(c) Reduce the transverse granularity, i.e., increase the pitch of scintillator strips. A small increase in strip width would not require major engineering changes, but it would yield only minimal cost savings; we would have to compensate for decreased light output if strips were made much wider than the 4 cm of the baseline design. In addition, the ultimate physics capability of the experiment could be compromised by a reduction in transverse granularity.

2. **Decrease far detector cavern size**

We are reluctant to make any major reduction in the Soudan cavern size, even if the mass (length) of the detector is reduced, because such a modification would be irreversible. A shorter Soudan cavern would seriously limit possibilities for the future evolution of the physics program if neutrino oscillations are discovered within the range of MINOS sensitivity.

3. **Technical changes**

These fall naturally into two categories:

(a) Improvements in the current design. A careful examination of the baseline design has already allowed us to identify some modifications which could reduce costs with no impact on physics capabilities. We are now reexamining all aspects of the design to identify savings of this type. However, it is unlikely that these will save more than $1M.

(b) Major modifications of the design. Preparation of this Technical Design Report, and the associated engineering and cost estimate studies, have identified several areas where costs are substantially higher than our original estimates. We are now in a good position to evaluate alternative implementations which could result in cost reductions. Some areas where large cost savings may be possible are the use of smaller-area near detector steel planes, alternative light collection and transmission schemes, and alternative photodetectors.

4. **Staging options**

One of the most attractive cost reduction strategies is to stage some aspects of the detector construction. Specifically, we could design the detector in such a way that its full capabilities are not available initially, but could be added in a future upgrade program if justified by physics developments. One example of such a strategy is to implement only one-ended readout of scintillator strips initially, but to construct the scintillator modules in such a way that an upgrade to two-ended readout is possible in the future. Such a change could yield large savings because it reduces by half the numbers of electronics channels and photodetectors, and it eliminates much of the fiber routing hardware. We are now investigating the effect of such a change on the physics sensitivity of the experiment.

5. **Contributions from other sources**

We expect to achieve some reduction in the funding needed from U.S. sources by obtaining some detector components from abroad. For example, we are actively exploring

with our Chinese collaborators the possibility of having them assume responsibility for some of the more labor intensive components. We are also investigating the possible reuse of existing equipment from other experiments, e.g., hardware from the MACRO laser calibration system.

Our strategy is to pursue several of these possibilities in parallel, with the goal of reducing the cost as much as possible without compromising the experiment's physics capability. If additional cost reduction is still needed, we will decrease the number of planes in the far detector until the estimated cost falls within the funding guidelines.